Dynamic Origin of Stripe Domains

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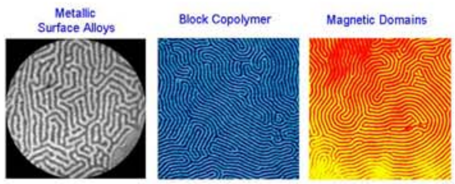
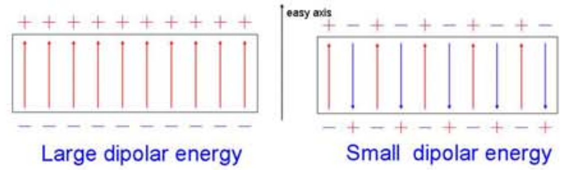
Motivation



Stripe domains are common to a wide variety of physical phenomena. They are known to arise from an interplay between short- and long-range forces.

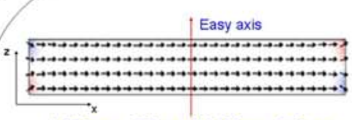


In ferromagnetic thin films, the formation stripe domains (right) is usually understood as the requirement to minimize the total energy - mainly the dipolar energy.

Our dynamical studies show that the stripe domain structure at remanence is related to a soft mode instability - not energy minimization.

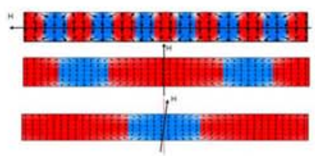
Major Accomplishments

Energetics fails

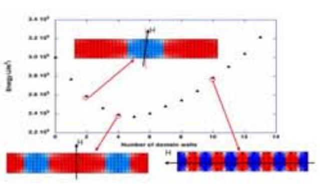


L=792 *nm* or 936 *nm*, *W*=120 *nm*, *T*=40 *nm*.

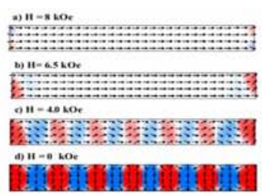
The system we studied is an anisotropic Co bar which is known to develop stripe domains at remanence.



In calculations, we find that the number of domains at remanence depends on field history.

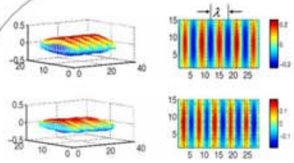


None of the three domain structures shown above is in the lowest energy state. **This indicates that energy minimization is not adequate to predict the stripe domains at remanence!**

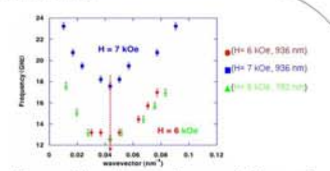


The pictures above show the magnetization evolution as the field along the bar is reduced.

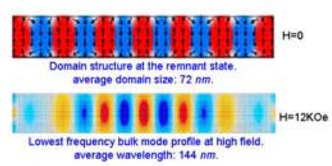
Dynamical study



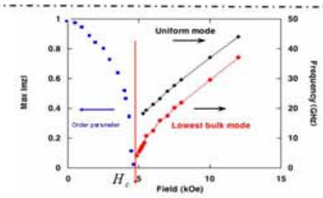
Simulations enable us to calculate the magnetic normal modes in ferromagnetic samples.



From the dispersion relation of the standing waves of the Co bar, we find one mode with a particular wave vector which always has the lowest frequency.



The lowest frequency standing wave mode at high fields has very similar spatial profile as the stripe domains at zero field!



The lowest frequency mode goes soft at a critical field, where the stripe domain structure starts to emerge. **Thus, the stripe domain structure at remanence originates from a zero frequency, standing wave mode.**

Summary

- **The stripe domain structure of a Co bar at remanence is not the lowest energy state.**
- **The wavelength of the lowest bulk mode at high fields coincides with the domain size at remanence.**
- **Stripe domains originate from a 2nd order phase transition characterized by a soft mode.**

Future Directions

To explore if other stripe domain structures are universally related to corresponding soft mode instabilities

G. Leaf, H. Kaper, M. Yan, V. Novosad, P. Vavassori, R. E. Camley, and M. Grimsditch, Phys. Rev. Lett. 96, 017201 (2006).

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